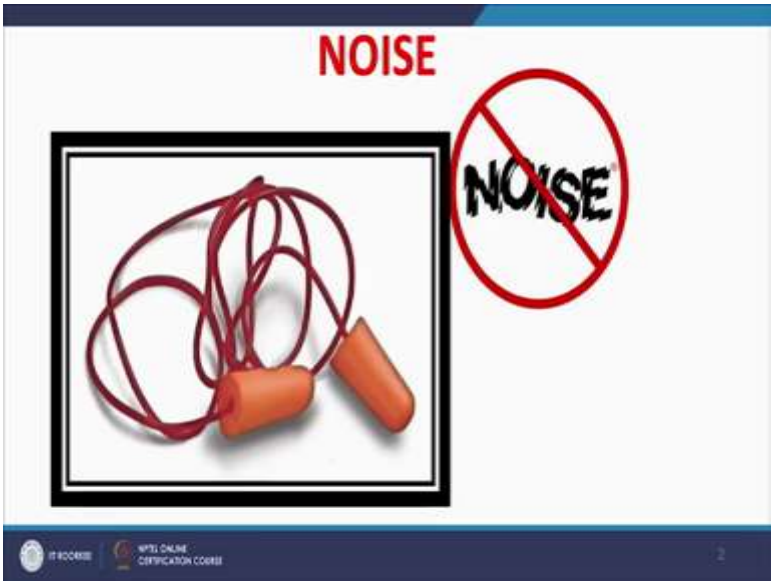
Chemical Process Safety
Professor Shishir Sinha
Department of Chemical Engineering
Indian Institute of Technology Roorkee
Lecture - 14
Noise, Vibration and Radiation

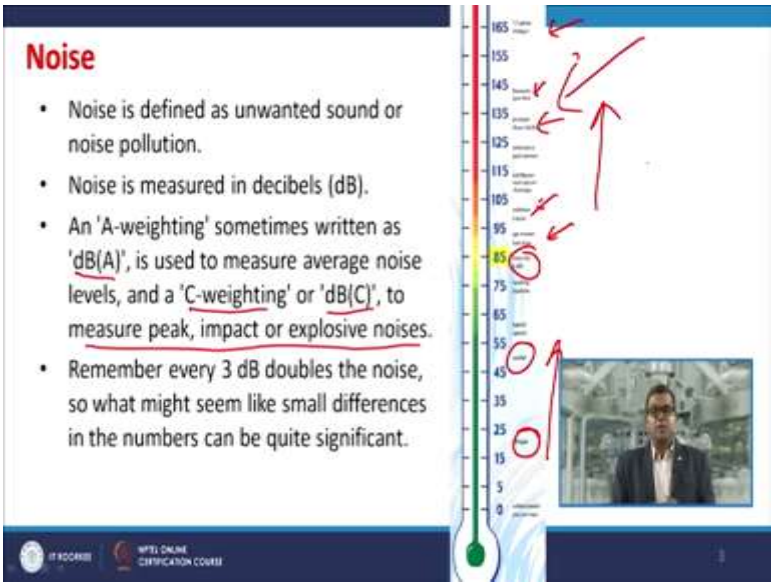
Welcome to the Noise and Radiation module of the Industrial Hygiene, in the previous module we studied the different methods of evaluation of toxic vapors from different type of scenarios.

(Refer Slide Time: 0:40)



In this particular module we will discuss about the gravity of noise pollution as well as the radiative pollution. Now, noise is very dangerous thing because in workplace you may experience different type of noises, sometimes it is irritating, sometimes it is pleasing etc. So, one must be aware about that what kind of precautionary measure he or she needs to take when it exceeds a particular limit.

(Refer Slide Time: 1:14)

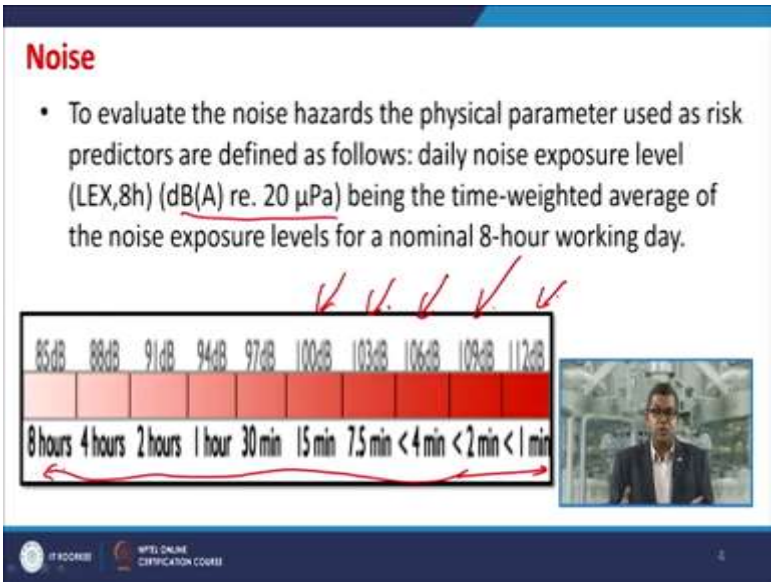


So, what is noise? Noise is defined as unwanted sound or noise pollution, this is usually measured in decibel. Now, an 'A–weighting' sometime written as dB inside the bracket A' and used to measure the average noise level and 'C–weighting' is 'dB C' to measure the peak impact or explosive noise.

In this particular figure you can see the various noise level of different activities like soft sound you can hear that is having a maybe a 0 decibel, upto 5 etc. Then whispering, rainfall, busy city traffic it is up to 85 sometimes you may experience that horn etc they are quite irritating, then gas manure, walkman tractor, etc jet plane, firework, gunshot, 20 gauge gunshots, etc. So these are some of the sounds these sounds are sometimes it is a present and these are quite irritating.

So, remember, every three decibels doubles the noise. So, what might seem like smaller difference in the number can be quite significant. So you must know that at workplace what are the permissible limit, how we can calculate and how we can protect our workers and what is the gravity of those over noising?

(Refer Slide Time: 2:44)



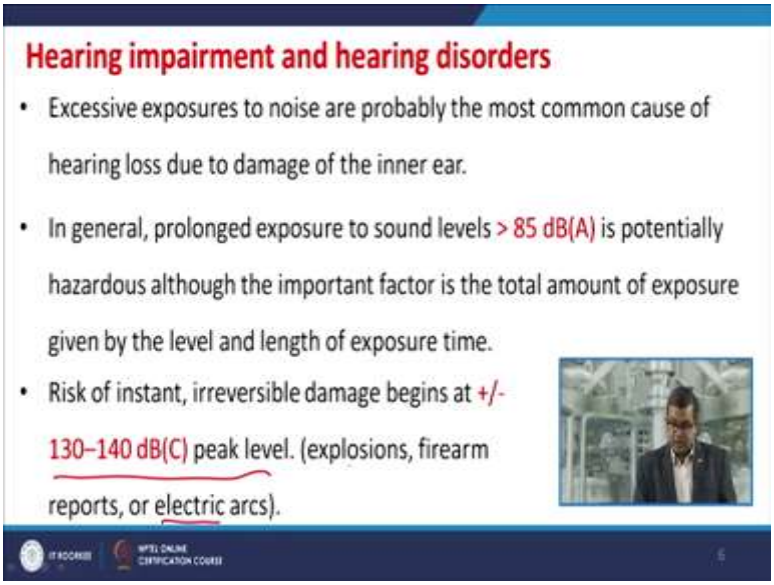
Now, to evaluate the noise hazard the physical parameter used as a risk predictors; they are defined as follows, the daily noise exposure level, let us say for 8 hour the dBA is 20 being the time weighted average of the noise exposure level for a normal 8 hour working day.

So, you can see this particular chart from say 12 decibels, 9 decibels, 6 decibel, 3 decibels, 0, etc and simultaneously, this is the time indicator which indicates that up to what is the duration of that particular exposure to the human being or that particular exposure to the worker which is who is working in that particular area.

(Refer Slide Time: 3:24)

Now, there are certain adverse effect of the noise, sometimes hearing impairment and hearing disorders if you are continuously being exposed to the heavy noise or high noise or beyond 85 decibels noise, there are certain effect on the noise and the pregnant workers there may be a certain work related stress, there are certain influence on work task, sometimes disturbance on speech communication, noise is a cause of certain accidents, and sometimes it's quite irritating, it may impart other health effects.

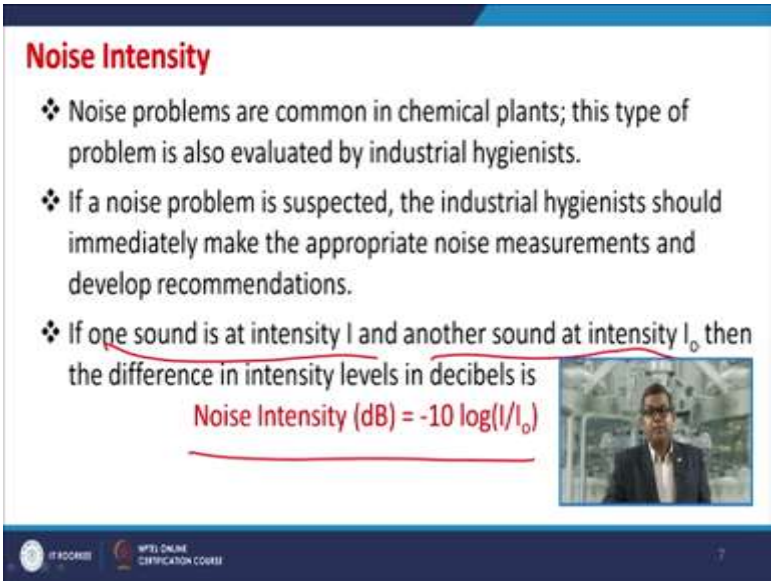
(Refer Slide Time: 4:06)



Now hearing impairment and hearing disorders usually they are excessive exposure to noise are probably the most common cause of hearing loss due to damage of inner ear. In general, the prolong exposure of sound that is greater than 85 decibel is potentially hazardous, although the important factor is the total amount of exposure given by the level and length of exposure time.

So, risk of instant, irreversible damage begins at ± 130 to 140 decibel in a peak level may be due to attributed due to the explosion, firearm reports or electric arcs etc. Because these are, sometimes these like electrical arcs and explosion, they are common in various chemical industries.

(Refer Slide Time: 5:04)



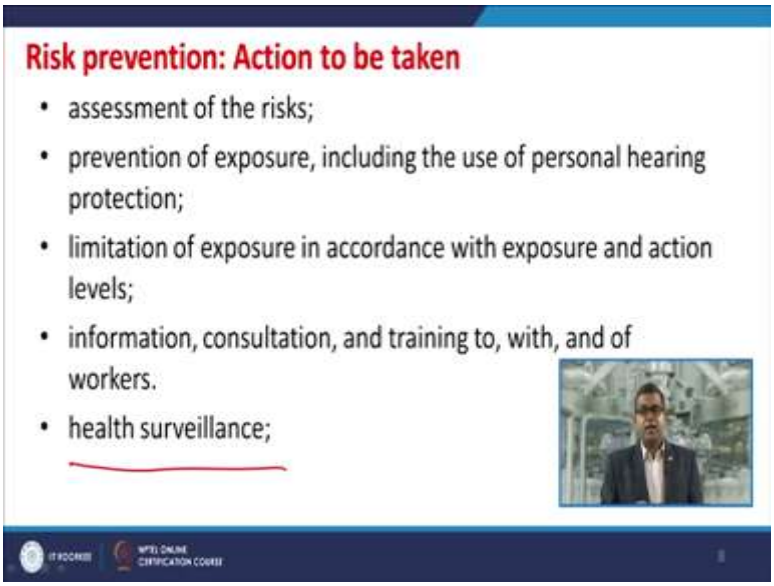
How we can calculate the noise intensity? Because noise problems are common in chemical plant and this type of problem is also evaluated by industrial hygienist. Now, if noise problem is suspected, the industrial hygienist or the chemical engineers should immediately make the appropriate noise measurement and develop the recommendation.

Now question arises how we can measure the noise? Now, this is a standard formula for the calculation of, or measuring of noise intensity in decibel that is equal to

Noise Intensity (dB) = $-10 \log(I/I_o)$

where one sound is having the intensity I and another sound is having the intensity I naught, I naught you may referred as the standard noise intensity through which you can calculate the noise intensity and find out that whether it is beyond the limit or if it is within the limit, if it is the beyond the limit then definitely you need to take some appropriate measures.

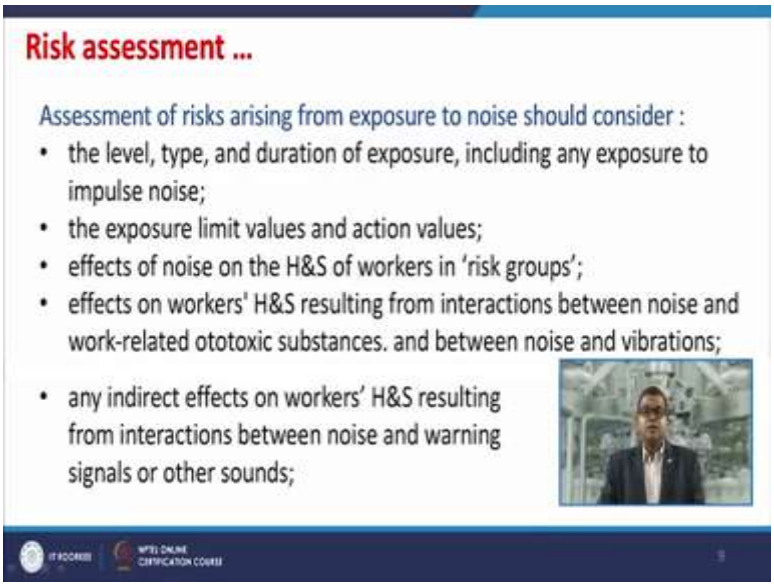
(Refer Slide Time: 6:06)



So, as far as the noise risk is concerned, what kind of action needs to be taken? First you assess the risk that how much is the risk based on your theoretical calculation, based on the human perception with those who are working within the arena. Prevention of exposure including use of personal hearing protections, limitation of exposure in accordance with the exposure and action level, sometimes some pulley, sometimes some moving part because of lack of lubrication, sometimes they are creating some irritating sound.

So, by application of usual techniques, you can reduce the noise intensity and if it is not workable then information, consultation and training to do with and off workers and above all, you must go forth health surveillance, so, that you can aware and future no problem can be created.

(Refer Slide Time: 7:14)

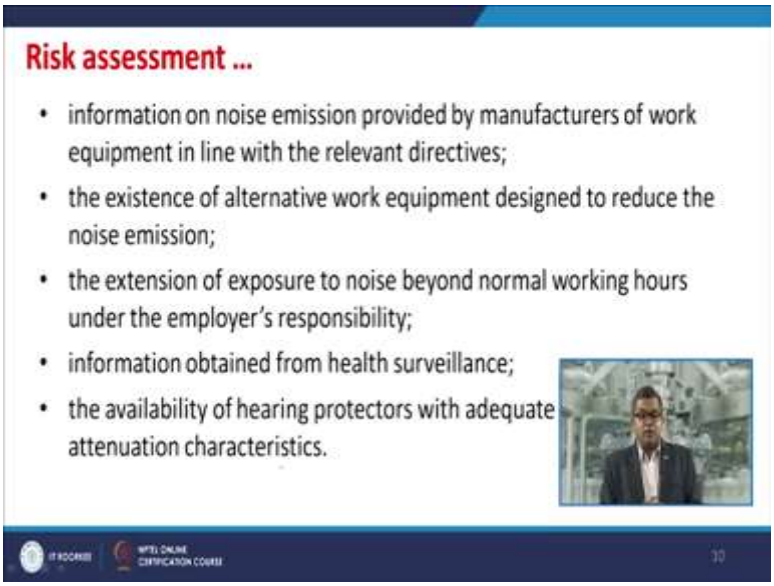


Assessment of risk arising from exposure to noise should consider the level what is the level of noise intensity, which type of noise intensity or which type of noise pollution is there and what is the duration of exposure of that particular irritating noise. This includes any exposure to the impulse noise, sometimes the fraction of second of noise may create a problem.

You must know the exposure limit values and action values because you cannot reduce the noise intensity of a gunshot, you cannot reduce because these are inherent property, so you need to adopt the appropriate measure, you must know the effect of noise on health and safety of the worker in the risk group, effects on worker health and safety resulting from interaction between the noise and work related ototoxic substance between the noise and vibration and sometimes vibration may create a problem in the subsequent in this particular module we will discuss this vibration aspect also.

Any indirect effect on worker's health and safety resulting from interaction between noise and warning signal or other sounds this is very important.

(Refer Slide Time: 8:26)

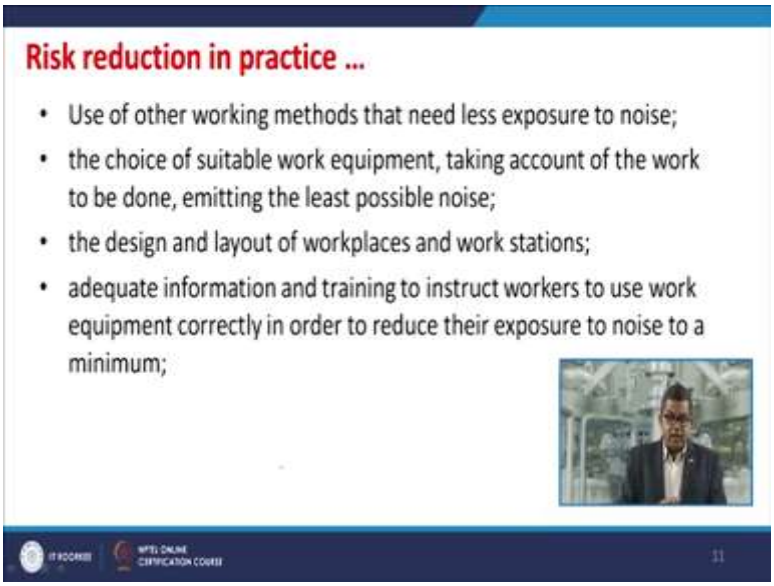


Information on noise emission provided by the manufacturer of work equipment in line with the relevant directives. Now, this is again very important because if prima facie you know that what is the noise intensity and suppose it is beyond the workable limit say 90 decibel, 95 decibel then you are mentally prepared to adopt different type of control measures to reduce that intensity to the human being.

The existence of alternative work equipment designed to reduce the noise emission, the extension of exposure to noise beyond normal working hour under the employers responsibility, you must aware because they are, if they are over exposed then you need to take the precautionary measures.

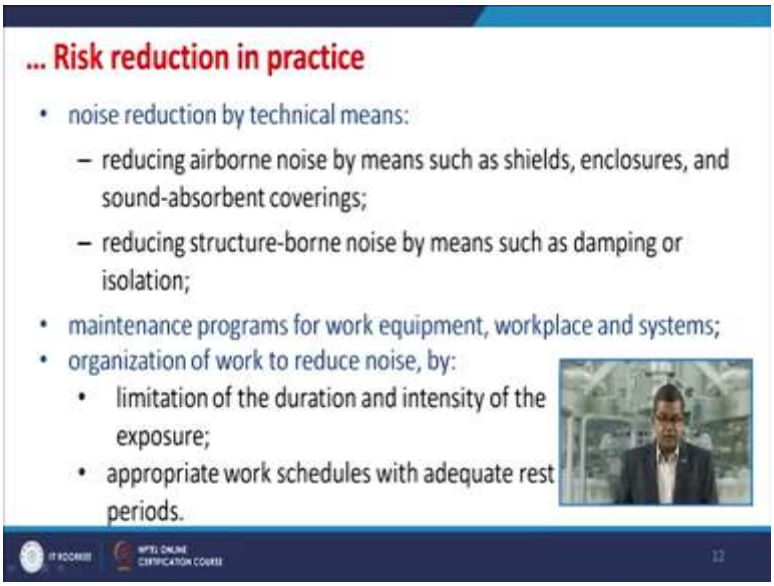
Information obtained from health surveillance, sometimes you are acclimatized to the noise radiation. So, you have to go for the medical checkup of your workers, so that (they) you can analyze that something, something wrong is going on within the system and you can be aware of this particular aspect. The availability of hearing protectors with adequate attenuation characteristics.

(Refer Slide Time: 9:40)



Risk reduction in practice, that is you may use of other working methods that need less exposure to the noise, sometimes good housekeeping like application of proper lubricant (may create) may reduce this problem. The choice of suitable work equipment, taking account of work to be done emitting the least possible noise. The design and layout of workplaces and workstations, sometimes it is very fruitful, because if the intensity of noise is we can say the distributed then definitely the problem to the worker may be reduced. The adequate information and training to instruct the workers to use work equipment correctly in order to reduce their exposure to noise to a minimum one.

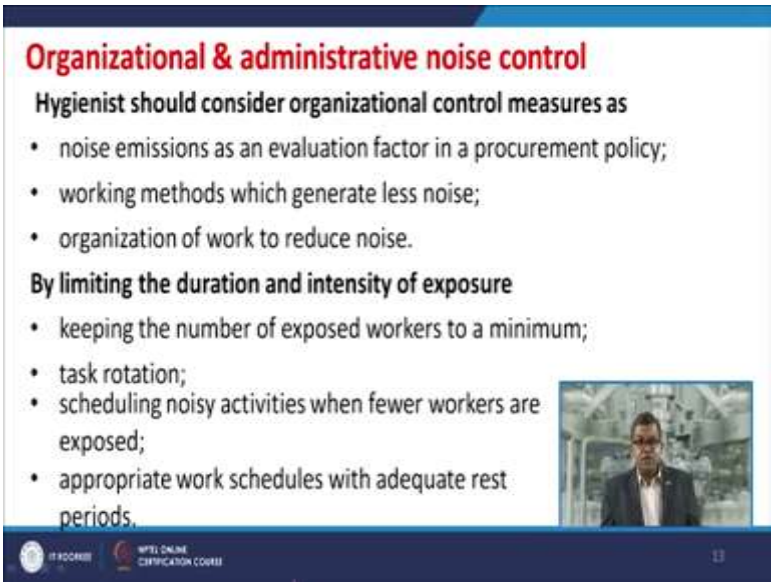
(Refer Slide Time: 10:30)



Now, noise reduction by a technical means, that is a reducing the airborne noise that is the noise at the workplace means such as shields, enclosures, there may be there are use of certain sound absorber or sound absorbent covering, etc. Sometimes to reducing structure-borne noise by means of such as damping or isolation. So you may adopt any kind of technique.

Maintenance program for the work equipment workplace and systems. One best example is go for good maintenance, like lubricating of any moving part. Organization of work to reduce noise by limitation of duration and intensity of exposure. Sometimes you are bound by the inherent property of any equipment which is producing noise, then you may limit the duration intensity of the exposure, of your workers. Appropriate work schedule with adequate rest period, so that they may acclimatize to that scenario.

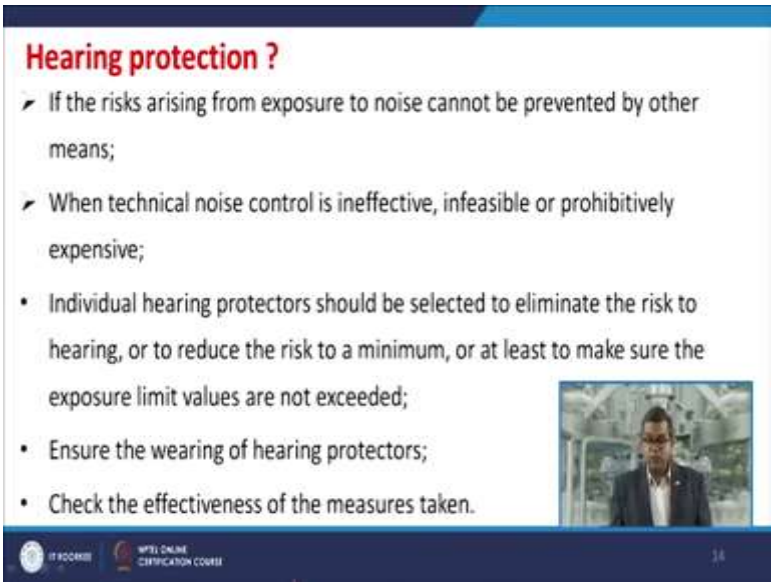
(Refer Slide Time: 11:44)



In this particular slide we will discuss about the organizational and administrative noise control. So, engineer or hygienist should consider organizational control measures as noise emission as an evaluation factor in procurement policy. So, once you are procuring any equipment, you must aware that what is the noise level, etc. Working method which generates less noise that is a good housekeeping or a working practice, etc. Organization of work to reduce the noise, etc again it is attributed to the good housekeeping and adopting a better policy for low noise.

By limiting the duration and intensity of exposure keeping the number of exposed workers to a minimum. You may adopt the policy of task rotation, so, that one person cannot be attributed to the high noise level. Scheduling noisy activities when fewer workers are exposed so that the impact to the mass population may be eliminated. Appropriate work schedule with adequate rest period. So, that the body can go up to the normal level.

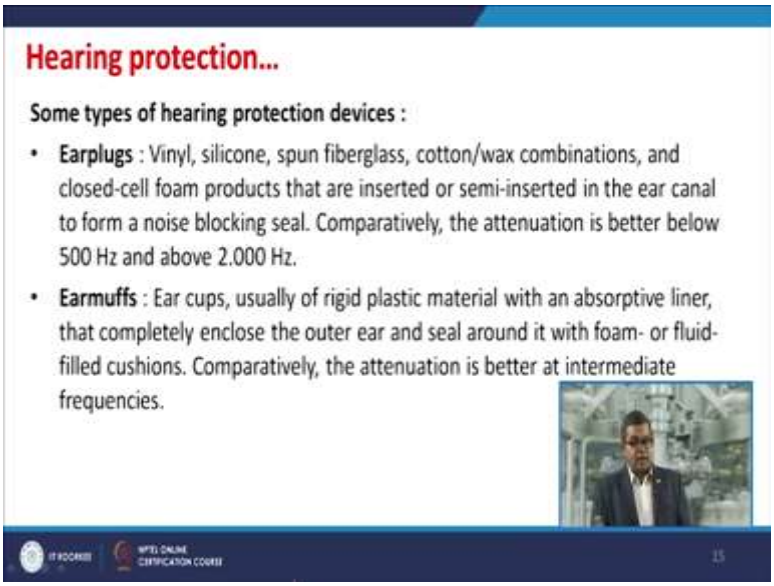
(Refer Slide Time: 12:56)



You may adopt certain hearing protection, if risk arising from exposure to noise cannot be prevented by other means, then definitely you must have a hearing protection. When technical noise control is ineffective because remember everywhere there is some inherent noise level. So, when technical noise control is ineffective, infeasible or prohibitively expensive. So, sometimes you need to optimize among all three parameters.

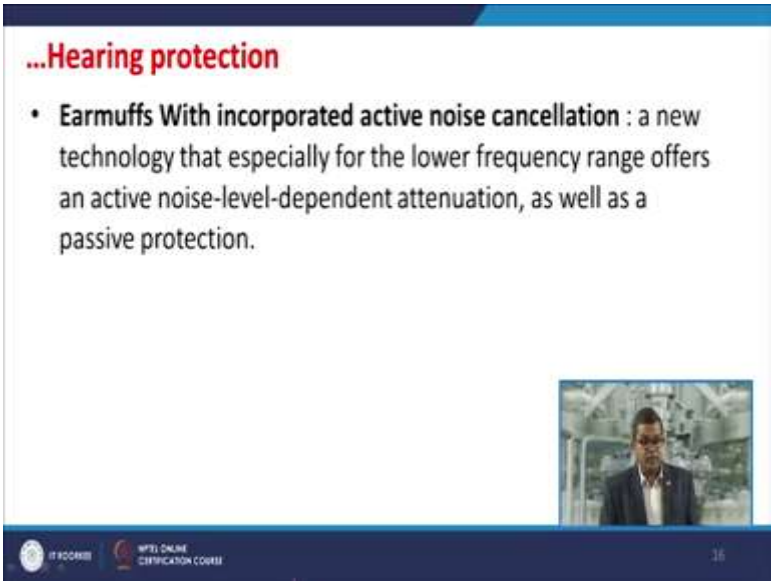
Individual hearing protectors should be selected to eliminate the risk to hearing or to reduce the risk to a minimum or at least to make sure the exposure limit values are not exceeded. Ensure the wearing of hearing protectors based on the requirement. Check the effectiveness of the measures taken and you need to perform the reviews and based on those reviews submit the report to the organizational head.

(Refer Slide Time: 13:48)



There are some types of hearing protection devices like earplugs usually they are vinly, silicone, spun fiberglass, etc and cotton wax combination, maybe the closed-cell foam product that are inserted or semi inserted in the ear canal to form a noise blocking seal, etc. There are certain earmuffs, there are ear cups usually the rigid plastic material with an absorptive liner that completely enclosed the outer ear and seal around with the foam or fluid filled cushions. Comparatively, the attenuation is better at intermediate frequency.

(Refer Slide Time: 14:22)

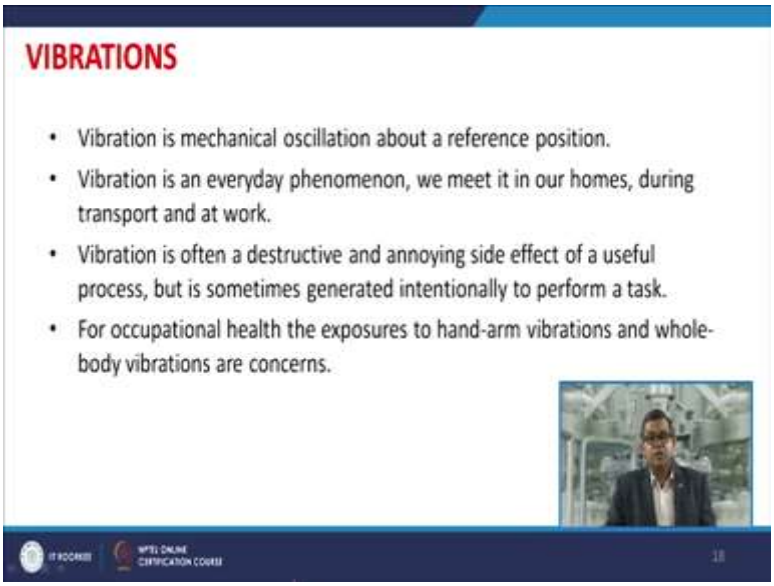


Some earmuffs with incorporated active noise cancellation, these are new technology that are especially for the lower frequency range; offers an active noise level dependent attenuation as well as passive protection.

(Refer Slide Time: 14:42)

In this particular aspect, we will discuss the gravity of vibration, because not only noise the vibration may create a problem and some equipments and some devices they are highly vibration prone. So, we must know that what is the importance of (this) these vibration to the human body and how we can eliminate these vibrations.

(Refer Slide Time: 14:56)

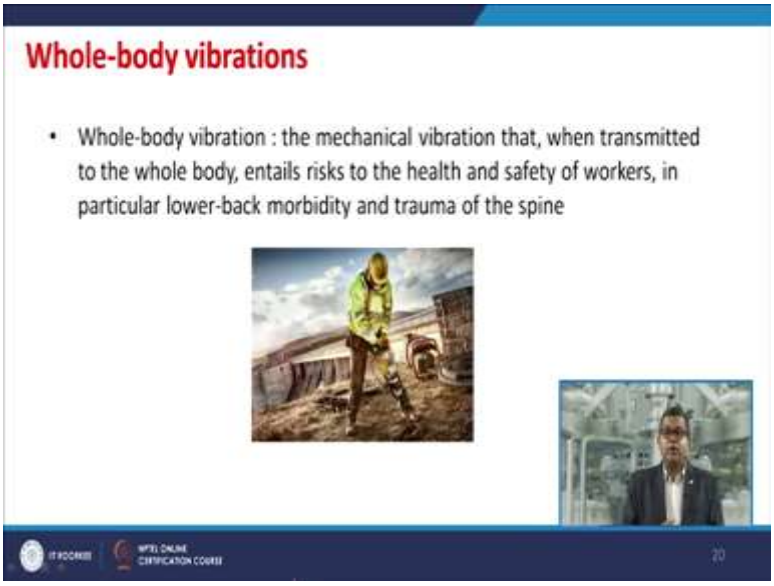


So, what is vibration? Vibration is a mechanical oscillation about a reference position. This is an everyday phenomenon and (we meet) sometimes we meet in our home during the transport or a work, etc. Even your mobile, your mobile phone; they call at the massive vibration frequency. So, vibration is often a destructive and annoying side effect of a useful process. But it sometimes generates intentionally to perform a task. It is the best example is your mobile. For occupational health, the exposure to hand-arm vibration and the whole body vibrations are concern.

(Refer Slide Time: 15:48)

Now, first let us take the hand-arm vibration. So the hand-arm vibration, the mechanical vibration that when transmitted to human hand-arm system, entails risk to the health and safety of have workers, in particular vascular bone or a joint or neurological or (muscle) muscular disorder. So, we must know these hand-arm vibration.

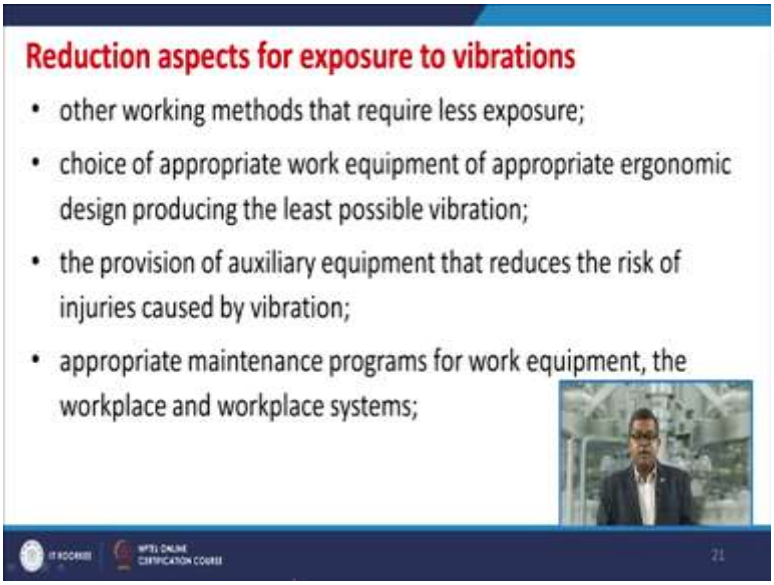
(Refer Slide Time: 16:12)



There are certain whole body vibrations, the mechanical vibrations that when transmitted to whole body, entails risk to the health and safety of the workers and particular lower back

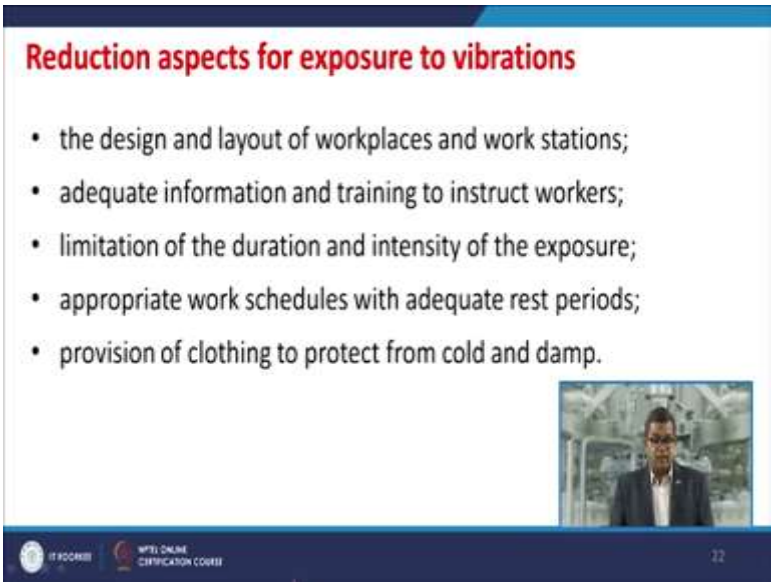
morbidity and trauma of spine, etc. So these are the extremely dangerous and may create a future health problem.

(Refer Slide Time: 16:36)



Then reduction aspect of exposure to vibration. Other working methods that require less exposure. Choice of appropriate work equipment or appropriate ergonomic design producing the least possible vibrations. The provision of auxiliary equipment that reduces the risk of injuries caused by vibration. The appropriate maintenance program of work equipment, the workplace and the workplace system.

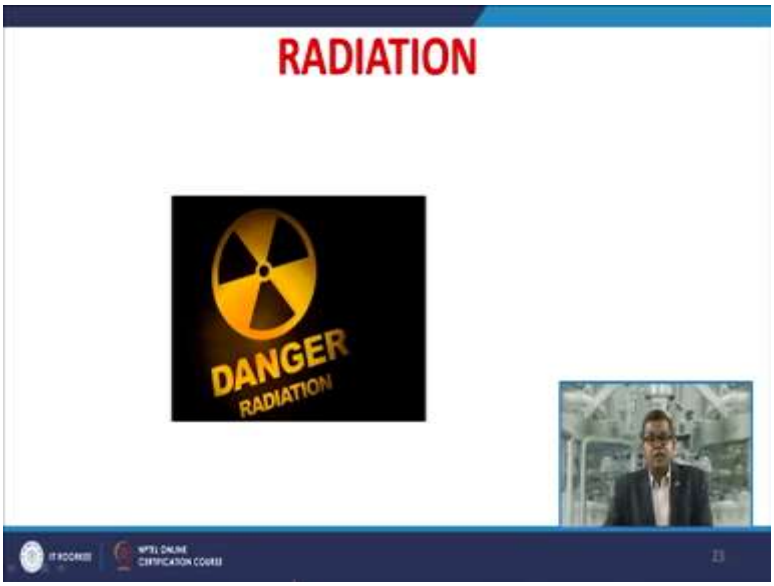
(Refer Slide Time: 17:06)



The design and layout of workplace and work station in such an efficient manner, so that it may, may reduce the adverse effect of vibration, there are certain vibration absorbers, etc. Adequate information and training to instruct the worker, this is extremely essential, because it is the right of worker to know that what are the hazards present at my workplace.

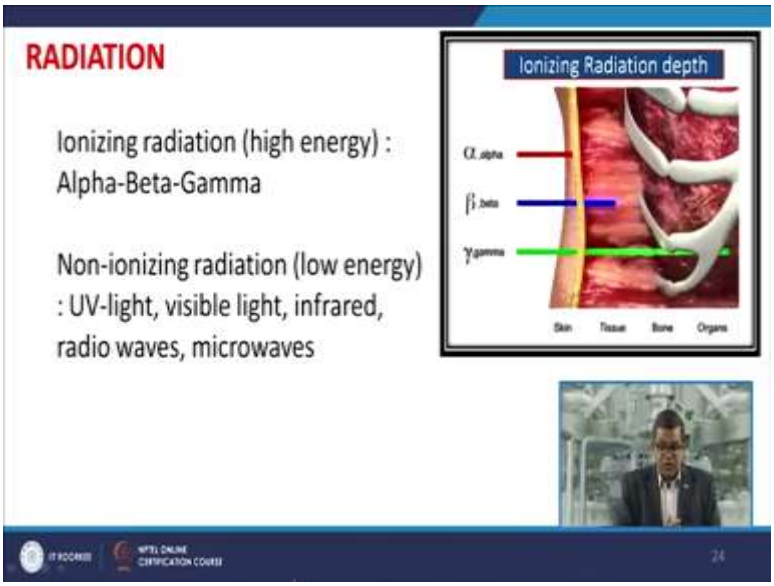
Limitation of the duration and intensity of the exposure, this is again a very crucial aspect. Appropriate work schedules with adequate rest period because this is again essential, so that your body attains a natural state before ready for another job. So provision of clothing to protect from cold and damp because again may create a health problem.

(Refer Slide Time: 18:10)



The last segment of this particular module is the radiation, there are so many equipments, there are so many things that workplace in the especially chemical industries, those involve the radiation and radiation is extremely dangerous, sometimes the effects are spontaneous, and sometimes it may create a future health problem. So, everybody should know that (what is the) what kind of radiation present at the workplace, whether they are properly notified, and how to protect yourself and your worker from the imminent danger of radiation.

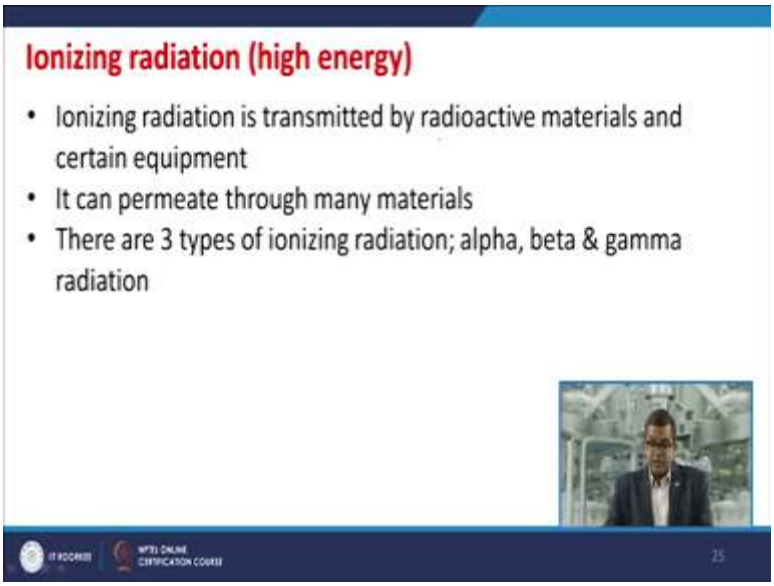
(Refer Slide Time: 18:54)



Now usually radiation, there are two types of radiation. I am not going to detail because it is beyond the domain, ionizing radiation, they are having very high energy like alpha, beta, gamma type of radiation. Non-ionizing radiation, they possess very low energy like UV-lights, visible light, infrared, radio wave, microwave these are the most common thing.

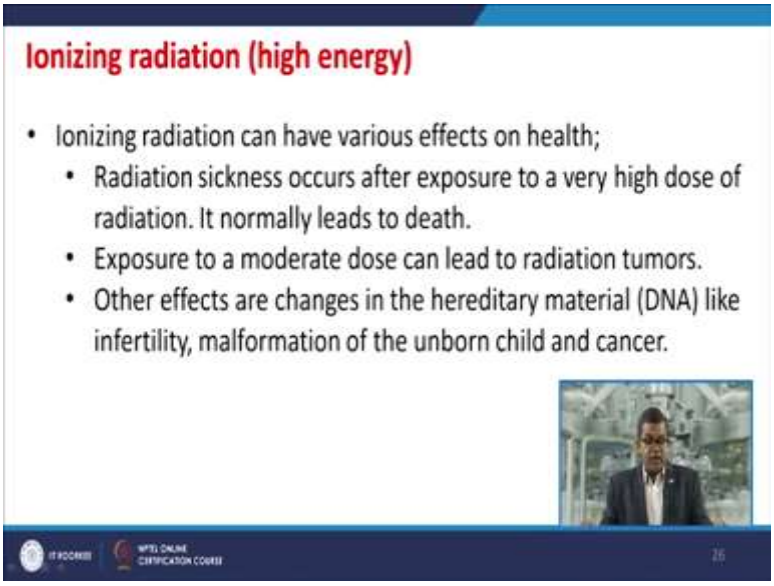
So, you can see in this particular figure that what is the intensity of ionizing radiation depth, gamma ray they can be penetrated more even up to the organ, this is the skin, tissues, bone, organs, beta radiation, it can go up to the tissue level and alpha it is up to the skin level. So, you must be aware that what kind of radiation is present at your workplace.

(Refer Slide Time: 19:46)



The ionizing radiation is transmitted by radioactive materials and certain equipments. So, it can permeate through many materials. So, there are three types of ionizing radiation, alpha, beta and gamma we have discussed in the previous slides and their intensity to the human being because we are more concerned towards the human being.

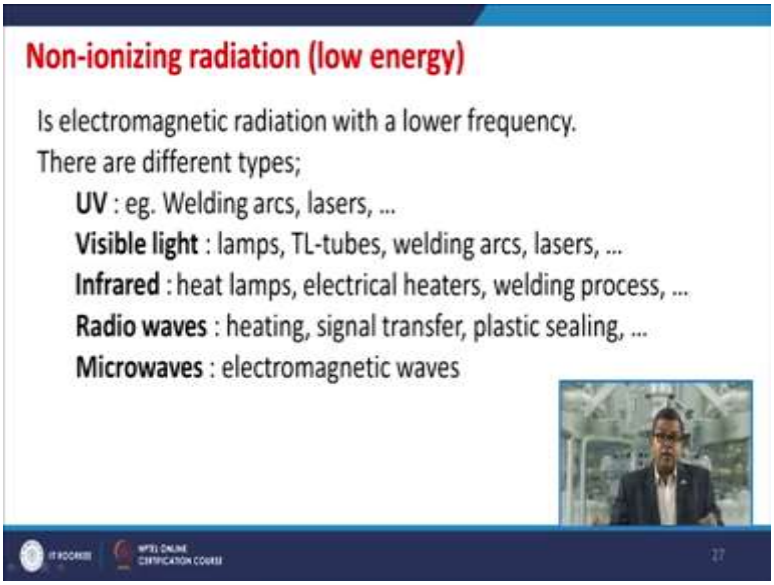
(Refer Slide Time: 20:10)



These radiations can have various effect on health, the radiation sickness occurs after exposure to a very high dose of radiation, it normally lead to death. Exposure to a moderate

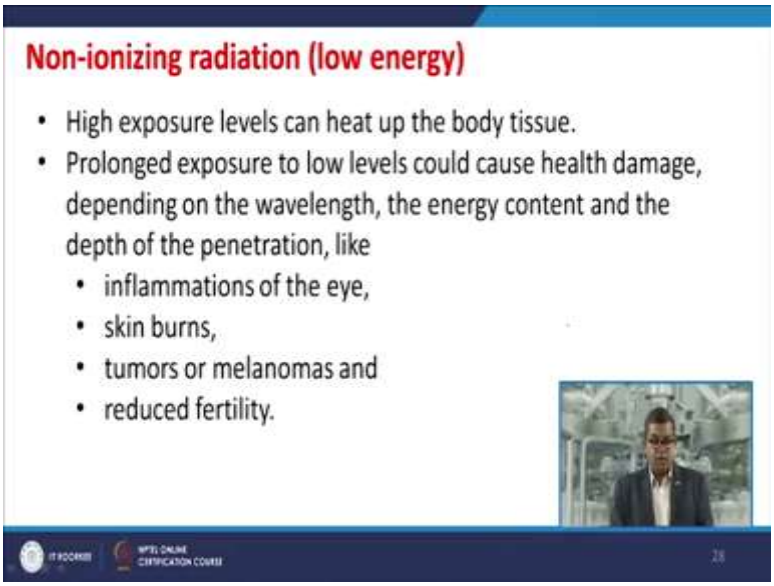
dose can lead to a radiation tumor and again the future effect of those tumor are extremely dangerous. The other effects are change in the hereditary material like DNA, infertility, malformation of the unborn child or a fetus and a cancer this one is again a more common,

(Refer Slide Time: 20:50)



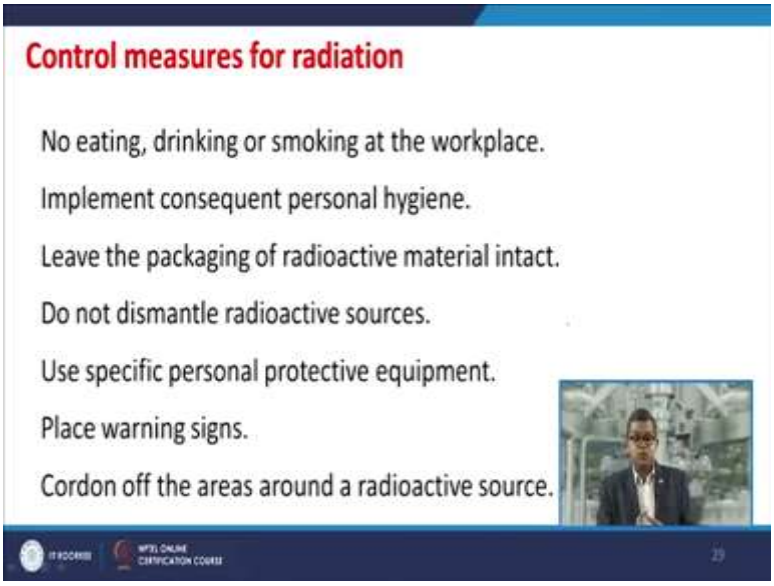
Non ionizing radiation they possess a very low energy, now is electromagnetic radiation with a lower frequency, there are different type like UV, like welding arc, laser, etc. Visible lights they are certain lamps, tube lights, welding arc, laser, infrared, heat lamps, electrical heaters, welding processes, etc. Radio waves, heating, signal transfer, plastic sealing, etc. Microwaves more common in our household affairs, electromagnetic waves, etc. So, must know that what, what are the non-ionizing radiations at your workplace.

(Refer Slide Time: 21:40)



Their high exposure level can heat up the body tissues. Prolonged exposure to low level could cause the health damage and a future health problem, depending upon the wavelength, the energy content and the depth of penetration like inflammation of the eyes, skin burns, tumors, reduced fertility, etc. So, these are the some problems may created by non-ionizing radiations.

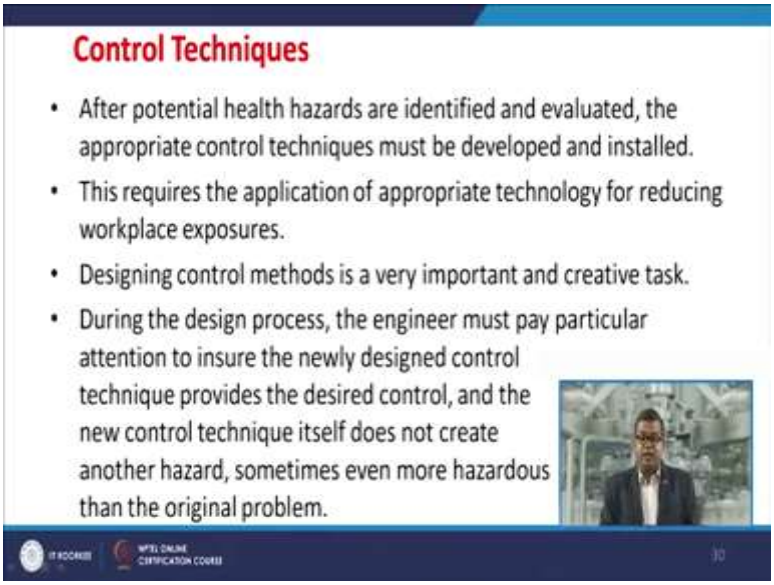
(Refer Slide Time: 22:12)



Now, what are the different control measures available for the radiations? No eating, drinking or smoking at the workplace, first thing because the if they changes, if they change your body energy level, then simultaneously they may change the food items or whatever you are taking in terms of drink, etc they may change the energy level. Implement consequent personal hygiene. Leave the packaging of radioactive material intact. Do not dismantle radioactive sources otherwise, it may create a problem. Use specific personal protective equipment, lead apron, etc and whatever being suggested by the supplier or whatever being, whatever being advised at the workplace.

The proper signage should be placed at the workplace. Cordon off the areas around the radioactive source by putting the work permit system and if work permit system, you adopt the permit system then you ensure that all, all the visitors plus the workers they are well protected.

(Refer Slide Time: 23:28)



After potential health hazards are identified and evaluated the appropriate control technique must be developed and installed. This requires the application of appropriate technology for reducing workplace exposure. The designing control method is very important and it is very creative task.

During the design process, the engineer must pay particular attention to ensure the newly designed control technique provides, that is why the safety reviews are essential. The new control technique itself does not create another hazard you must ensure sometimes even more hazardous than the original problem.

So, you must ensure that whatever control technique or newly controlled technique you are adopting, it should not create any future problems, sometimes you are eliminating the radiation problem by this way you are creating the vibrational or a noise problem. So, it should not be there.

(Refer Slide Time: 24:22)

Now, in other slides or in the subsequent module, we will discuss the various chemical plant control techniques. So, in this aspect the four basic parameters are there, one is the substitution; you must use the chemical and equipment which are less hazardous. Attenuation; use chemicals under condition which make them less hazardous maybe by reducing the vibration, maybe by reducing the temperature, maybe by reducing the pressure, etc.

Isolation; the isolate the equipment and the source of hazard, sometimes like it is equally applicable for the radioactive hazards, it is equally applicable for the vibrational hazards, it is equally applicable for the noise hazard, equally applicable for flammable hazards, etc.

Intensification; you must reduce the quantity of a chemical or you must reduce the quantity of those the equipment, those who are producing vibration, noise, radiation etc. So, these are the four basic parameters for any chemical plant control technique.

(Refer Slide Time: 25:32)

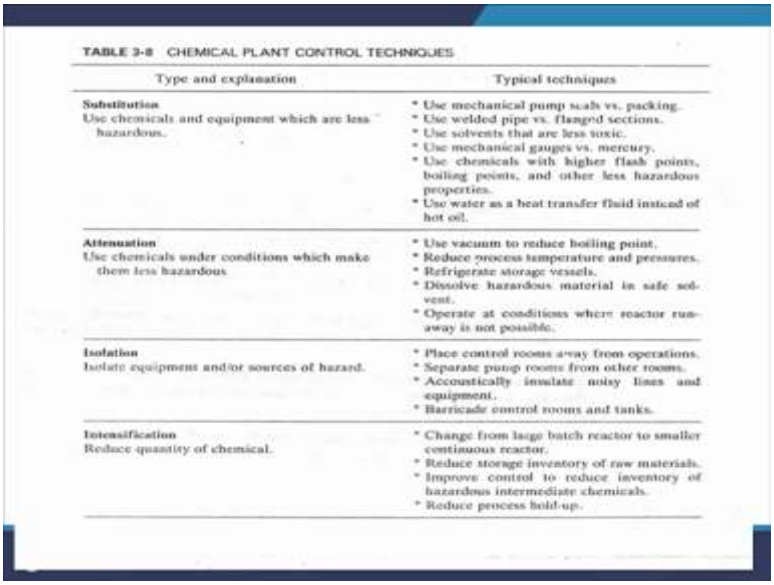


TABLE 3-8 CHEMICAL PLANT CONTROL TECHNIQUES

Type and explanation	Typical techniques
Substitution Use chemicals and equipment which are less hazardous.	* Use mechanical pump seals vs. packing. * Use welded pipe vs. flanged sections. * Use solvents that are less toxic. * Use mechanical gauges vs. mercury. * Use chemicals with higher flash points, boiling points, and other less hazardous properties. * Use water as a heat transfer fluid instead of hot oil.
Attenuation Use chemicals under conditions which make them less hazardous	* Use vacuum to reduce boiling point. * Reduce process temperature and pressures. * Refrigerate storage vessels. * Dissolve hazardous material in safe solvent. * Operate at conditions where reactor runaway is not possible.
Isolation Isolate equipment and/or sources of hazard.	* Place control rooms away from operations. * Separate pump rooms from other rooms. * Accoustically insulate noisy lines and equipment. * Barricade control rooms and tanks.
Intensification Reduce quantity of chemical.	* Change from large batch reactor to smaller continuous reactor. * Reduce storage inventory of raw materials. * Improve control to reduce inventory of hazardous intermediate chemicals. * Reduce process hold-up.

Now, in this particular table you can see that what kind of different types of chemical plant control techniques and what are the typical techniques being adopted to control the hazard, substitution, use chemical equipment which are less hazardous you may use the mechanical pump seal, you may use the welded pipe versus flanged sections, use solvents those who are less toxic, you may use the mechanical gauges versus mercury one (use chemical) because mercury is again carcinogenic, use chemicals with the higher flashpoints, boiling points, and other less hazardous properties, you may use water as a heat transfer fluid instead of hot oil because the it is having the high enthalpy.

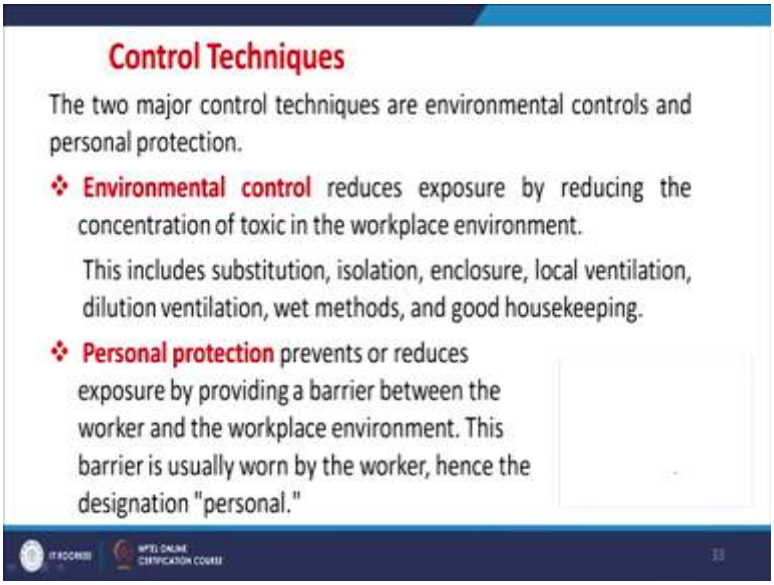
Attenuation, you may use the chemical under condition which make them less hazardous, you may use vacuum to reduce the boiling point, reduce pressure, temperature and pressure, you may refrigerate the storage vessel, dissolved hazardous material in a safe solvent, you may operate at conditions where the reactor run away is not possible.

These are some typical tasks. isolation; isolate the equipment and a source of hazard that is the place control room away from all kind of operation, separate pump rooms from other

rooms, acoustically insulate the noisy lines and equipment so that you can minimize the noise, noise intensity, barricade control rooms and tanks so that the vibration, radioactive hazards may not take place.

Intensification; you reduce the quantity of chemical that has changed from large batch reactor to smaller continuous reactor, reduce storage inventory of raw material, improve control to reduce the inventory of hazardous intermediate chemicals and you may reduce the process hold up.

(Refer Slide Time: 27:33)

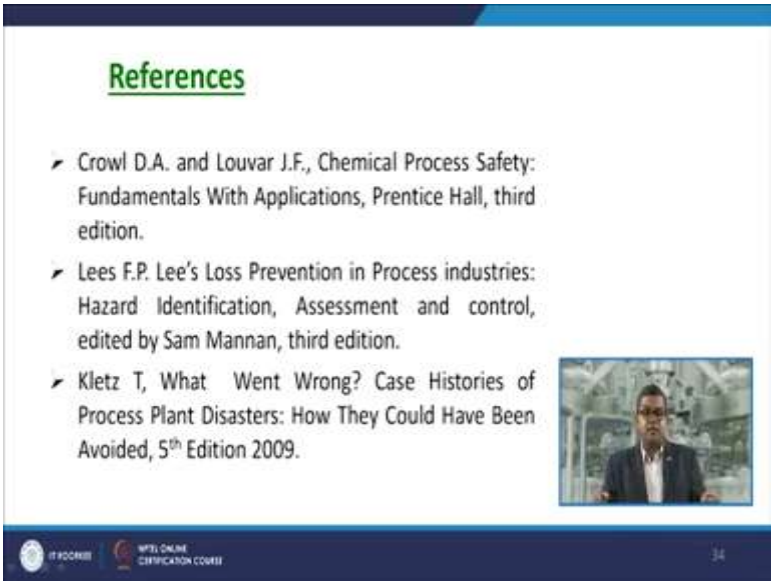


Now, when we talk about the control techniques, there are two major control techniques, one is the environmental control and the second one is the personal protection. Because as far as whenever you are dealing with all kinds of such toxic substance, noise level vibration, radiation, etc these two are extremely important. So, environmental control, this reduces the exposure by reducing the concentration of toxic in the workplace environment. This includes the substitution, isolation, enclosures, local ventilation, dilution ventilation, wet methods and good housekeeping.

The personal protection, this prevents or reduces the exposure by providing the barrier between the worker and workplace environment so that the worker cannot get exposed to the toxic environment, maybe in terms of noise, maybe in terms of chemicals, maybe in

terms of radiation etc. This barrier is usually worn by worker, hence designated as the personal one.

(Refer Slide Time: 28:44)



We will discuss these control methods in subsequent module and by the time in this particular lecture, whatever we have discussed. You can have the reference from the, these three reference sources or resource materials. Thank you.